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ABSTRACT

A demonstration project tested the efficacy of computer-assisted instruction (CAI) as a means of providing individualized in-service education in mathematics to elementary school teachers. Seventy-eight teachers were assigned to matched experimental and control groups; the former received a CAI version of the Modern Mathematics (Modmath) course on a system which used an IBM 7010-1448 computer configuration along with IBM 1052 Typewriter Consoles and IBM 1051 Control Units. The control group took a conventional lecture version of the course. Posttest results and observations indicated no significant differences between the groups with respect to achievement in math, attitude toward math, or teaching behavior in the classroom. CAI thus appeared to be a viable means of presenting in-service in mathematics since teachers using the program performed as well as those in the control group. It is likely that CAI has greater promise for the future because the programs can be further individualized to meet the specific in-service needs of teachers. Technical difficulties encountered were minimal and the results of the project were disseminated widely. (PB)

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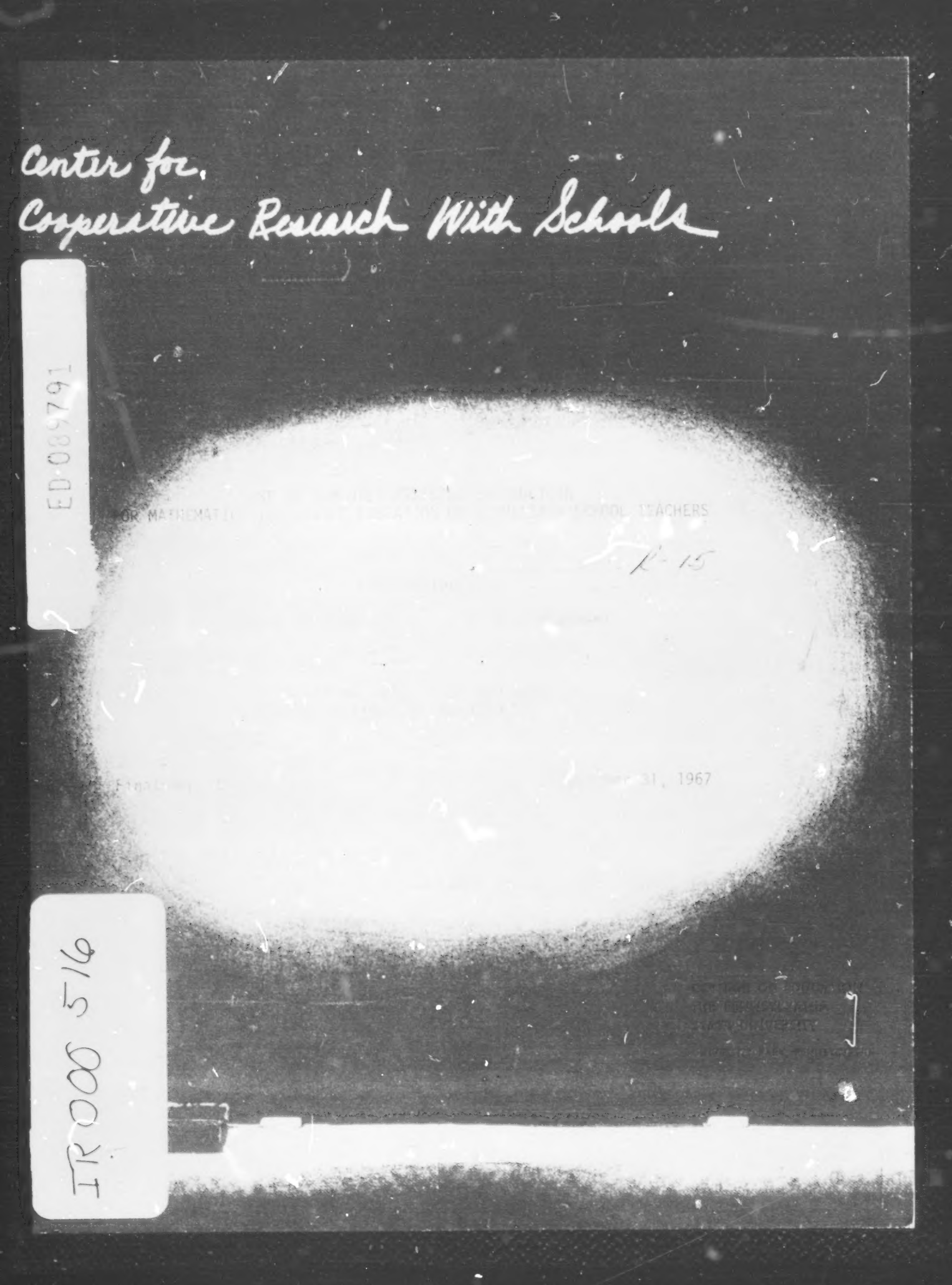

Note to accompany the Penn State Documents.

In order to have the entire collection of reports generated by the Computer Assisted Instruction Lab. at Penn State University included in the ERIC archives, the ERIC Clearinghouse on Educational Media and Technology was asked by Penn State to input the material. We are therefore including some documents which may be several years old. Also, so that our bibliographic information will conform with Penn State's, we have occasionally changed the title somewhat, or added information that may not be on the title page. Two of the documents in the CARE (Computer Assisted Remedial Education) collection were transferred to ERIC/EC to abstract. They are Report Number R-36 and Report Number R-50.

--- Jacklyn Crowell: ERIC/IR

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USE OF COMPUTER ASSISTED INSTRUCTION FOR MATHEMATICS IN-SERVICE EDUCATION OF ELEMENTARY SCHOOL TEACHERS

Co-Directors

Samuel M. Long C. Alan Riedesel

Grant No. OEG-1-7-661970-0383
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Final Report

October 31, 1967

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Use of Computer Assisted Instruction
For Mathematics In-Service Education of Elementary School Teachers

1. *Discuss the effect of the project on the clientele by briefly stating the major objectives of the project and the techniques used in evaluating the extent to which these objectives were achieved.*

Introduction

The primary purpose of the project was to demonstrate the use of computer assisted instruction as a means of conducting in-service education in mathematics.

It is no longer possible to consider that an elementary teacher's education is complete when he finishes a bachelor's or a master's degree. The rapid curriculum changes that began several years ago are continuing at an unprecedented pace making the effective in-service education of all elementary teachers imperative.

Mathematical associations and leading mathematics educators (Committee on the Undergraduate Program in Mathematics, 1963; National Council of Teachers of Mathematics, 1960; Stone, 1959; Mueller, 1959; Newson, 1951; Stepanowich, 1957; and Todd, 1966) have made suggestions concerning the needed mathematical preparation of elementary school teachers. Others have found that progress in up-dating the mathematics of elementary school teachers has been slow (Sparks, 1962; Riedesel, 1964).

Studies involving in-service education in mathematics for elementary school teachers strongly indicate that improvement in teacher background can be accomplished through in-service work. Huettig and Newell (1964) found that teachers with courses in modern mathematical content had a significantly better attitude toward curricular change in mathematics.

Rudd (1954) found in-service courses to be of a higher caliber when individual teacher background was taken into consideration and the in-service course was accomplished at the local level in close proximity to the elementary classroom. Houston, Boyd, and DeVault (1962) worked with 252 elementary teachers in a multi-media approach which used closed-circuit television, lecture, question-discussion and written materials. Teachers preferred the written materials and the question-discussion approach to teaching. The researcher states, "The findings of this study would indicate that administrators should consider procedures for individualizing in-service education programs for teachers."

Dutton (1966) also noted that use of programmed instructional materials seems to provide numerous opportunities to diagnose students' subordinate knowledge and skills essential for sound sequential learning and expansion of mathematical concepts. In another study, Dutton and Hammond (1966) stated that identification of weaknesses teachers have in understanding the new mathematics and teaching to overcome these weaknesses should be an important part of an in-service program. Meaningful instruction should be provided, and attitude development must be carefully considered.

In summary, the findings of research suggest that (1) in-service education in mathematics for teachers is needed, and (2) individualization for such in-service work is highly desirable.

The initial planning for this project began in April, 1965. Representatives of the Department of Public Instruction in Pennsylvania and The Pennsylvania State University met and discussed ways of solving the problems facing school districts in the Commonwealth regarding in-service education of teachers, especially elementary teachers. The use of

computer-assisted instruction (CAI) seemed to offer many advantages as a means of conducting individualized in-service education and to be highly innovative. In late 1965, the Williamsport Area School District indicated a need for in-service education in mathematics and its representatives were included in the planning.

The central equipment feature of CAI is a digital computer and relatively high-speed information retrieval and operating system. This makes use of a sophisticated type of programmed instruction presented via a computer-connected electric typewriter. The computer types information and questions and the student replies by typing his responses on the same machine. Computer programming allows for a variety of learning sequences which are based on the responses made by the individual student. Because of the branching nature of the CAI instructional format, teachers with varying backgrounds and/or abilities do not go through identical learning sequences. Learners who have an adequate background deal with major questions and are not presented remedial help, while those who need additional help are given a number of branching sequences to help them learn mathematical concepts.

The CAI course used in the project was Modern Mathematics (modmath), developed at The Pennsylvania State University by Dr. C. Alan Riedesel and Dr. Marilyn N. Suydam as part of a previous U.S.O.E. project.*

The course is based on the recommendations of mathematical associations and experts in elementary school mathematics education. It was originally designed for the pre-service education of teachers, paralleling a course (Math 200) being offered by The Pennsylvania State University. The

*The Development and Presentation of Four College Course by Computer Teleprocessing, Project No. OE-4-16-010.

content is presented in fourteen chapters, with the following descriptive titles: Sets; Relations; Exponents; Our Numeration System; Other Numeration Systems; Whole Numbers: Addition, Subtraction, Multiplication, Division; Integers; Rational Numbers: Fractions, Decimals, Ratio and Per Cent; and Real Numbers. A rationale for the strategies of the course, the course outline, and a sample of the course is contained in Appendices A, B, and C.

The conventional instruction group was taught by Dr. Riedesel, using the same course outline and other non-CAI materials.

Objectives

The major objectives of the program were.

1. To compare an in-service program offered via CAI with a program using conventional instruction. The programs were compared as to: (a) mathematical achievement, (b) attitude towards mathematics, and (c) teacher classroom behavior.

2. To provide an opportunity for demonstration to personnel from other school districts who may be interested in the future use of CAI.

3. To determine and document technical problems that may occur in the use of CAI for in-service programs.

4. To improve the existing modern mathematics course by analyzing and using detailed records of student performances.

Procedure

From Seotember, 1966 through January, 1967, four CAI student terminals consisting of IBM 1052 Typewriter Consoles and IBM 1051 Control Units were installed in the George Washington Elementary School in the Williamsport Area School District. These were student stations connected

via long-distance telephone lines to the IBM 7010-1448 computer configuration at the Thomas J. Watson Research Center, IBM Corporation, Yorktown Heights, New York. A fifth line for emergency uses was connected with the IBM 1410 computer on the University Park campus of The Pennsylvania State University. The program in modern mathematics was stored in both locations.

Seventy-eight teachers who had had no in-service work in modern mathematics were given a pretest which involved concepts of modern mathematics. After scores were rank ordered, the teachers were randomly assigned, pairwise, to CAI and conventional instruction groups. Attitude scales were also completed initially and at the time of the posttest.

After the period of in-service instruction, observations of the classroom behaviors of a random sample of teachers from each treatment group were conducted by a team of four observers.

The time schedule which was followed was:

1.	Installation of Equipment	September 22, 1966
2.	Project Orientation Meeting for Teachers	September 26, 1966
3.	Administration of Pretest and Atittude Scales	September 26, 1966
4.	Period of Computer Assisted Instruction	October 3, 1966-January24, 1967
	Period of Conventional Instruction	October 10, 1966-December 12, 1967
5.	Administration of Posttest and Attitude Scales	December 1, 1966-January 25, 1967
6.	Observation Period:	March, 1967-May, 1967
7.	Administration of Retention Test:	May 1, 1967
8.	Analysis of data and preparation of final report	June, 1967-August, 1967

Evaluation Procedures

Objective 1. *To compare an in-service program offered via CAI with a program using conventional instruction.* The programs were compared as to:

a) Mathematical achievement: This phase was evaluated by use of A Test on Modern Mathematics as the pre-, post-, and retention measure. The test was developed specifically for comparisons of the modern mathematics program by Dr. Riedesel and Dr. Suydam and is composed of fifty items selected from a pool of two hundred test questions on criteria of content validity, difficulty level, and an index of item discrimination. A copy of the test is contained in Appendix D.

b) Attitude toward mathematics: This phase was evaluated by two attitude scales, the Attitudes Toward Modern Mathematics Questionnaire (Appendix E) and the Reaction to Elementary School Mathematics Scale (Appendix F). These scales were completed by teachers in both treatment groups. In addition, the CAI teachers completed self-report inventories concerning their reactions to the program.

c) Teacher classroom behavior: The classroom behavior of teachers from each treatment group was observed by a team trained in the recording of classroom behavior by means of systematic observation. These observations were made to determine whether either treatment differentially affected the classroom behavior of the teachers. Buck's Observation Scale and Record for Elementary Mathematics (Appendix G), recently developed on The Pennsylvania State University campus, was used. A random sample of 20 teachers from each treatment group was observed six times.

The results of evaluation of objective 1 are presented in the next two sections.

Objective 2: *To provide an opportunity for demonstration to personnel from other school districts who may be interested in the use of CAI.*

This dissemination phase is documented in part 5. Included among the activities were a conference for area educators, news articles, speeches, and other contacts.

Objective 3: *To determine and document technical problems that may occur in the future use of CAI for in-service programs.* This phase was documented by logs kept by staff technicians. Technical problems were present but comparatively minimal as indicated by the fact that only 8.2% of available computer time was unused due to technical problems.

Objective 4: *To improve the existing modern mathematics course by analyzing and using detailed records of student performances.* Records of teacher responses and response latencies elicited by the programmed materials were available from computer log tapes. These tapes have been used to revise teaching sequences to increase the effectiveness of the modmath course with teachers in the future.

Achievement Test Results

The range of scores on the pretest on modern math was from 0 to 37, with a median of 16.0 and a mean of 15.57. On the basis of the scores, the group was stratified and then randomly assigned to one of the two treatments. The Lecture-Discussion Group consisted of 39 persons whose scores ranged from 0 to 37, with a median of 15.5 and a mean of 14.46. The CAI Group also included 39 persons, their scores ranged from 0 to 34, with a median of 16.5 and a mean of 16.69. Table 1 in Appendix H presents the frequency distribution for the total group, and for each of the treatment groups which follow.

The Lecture-Discussion Group met for two hours each week for ten weeks. At each of the meetings, a study guide containing related problems was distributed. Samples of these are included in Appendix I.

Each participant in the CAI Group was scheduled for two 75-minute instructional periods per week. Since each proceeded through the course at his own rate, some finished as early as November 28, 1966, while others did not finish until January 24, 1967. The fastest time was 14 hours 37 minutes, while the slowest was 46 hours 35 minutes. The mean was 25 hours 32 minutes. Appendix J contains a coded list of the group, with finish dates, test dates, and total time spent on the course. A summary of the on-line terminal usage is included in Appendix K.

The final meeting for the Lecture-Discussion Group was on December 12, 1966. After a final review, the posttest and attitude scales were administered. A list of pretest, posttest, and difference scores is presented on Table 2 in Appendix H while Table 1 in the same appendix contains the frequency distributions for the total group and each subgroup. The difference between the pretest mean of 14.46 and the posttest mean of 23.79 was 9.33.

Teachers in the CAI Group were tested within one week of their last computer session. In addition to the posttest and attitude scales completed by the other group, they also completed a final Student Attitude Toward Computer Assisted Instruction Scale contained in Appendix L. Table 3 in Appendix H contains a list of pretest, posttest, and difference scores for this group. The difference between the pretest mean of 16.69 and the posttest mean of 28.15 was 11.46.

The retantion test was administered on May 1, 1967. The range of scores for the Lecture-Discussion Group was from 7 to 42, with a median

of 22.8 and a mean of 22.55. For the CAI Group, the range was from 8 to 42, with a median of 26.0 and a mean of 26.40. Table 1 in Appendix H presents the frequency distribution on the retention test.

Additional statistical analyses are presented in detail in the next section.

Results of Analysis of Data

This section presents the results of the statistical analyses designed to compare the in-service program offered through CAI with the program using conventional instruction. Comparisons were made with respect to (1) modern math achievement, (2) attitude toward (a) elementary school mathematics and (b) modern mathematics, and (3) teacher classroom behavior.

All analyses were performed at The Pennsylvania State University Computation Center.

A correlation matrix showing the relationship among the variables for the total group is presented in Table 4 in Appendix M. By total group is meant the 67 teachers (34 taught by CAI method and 33 by the conventional method) for whom complete test and scale data are available. The correlation matrices for the CAI and conventional groups were quite similar to the one for the total group and, therefore, are not presented.

A search was made for variables that might be of potential use as factors or covariates in later analyses. It was decided that the potentially useful variables were characterized by generally low correlations with the dependent variables and did not appear to offer strong enough relationships to serve as efficient control variables.

One trend which may be noted is the consistent pattern of negative correlations between age (variable 16) and the achievement tests

(variables 1 - 3). For obvious reasons similar results were found between total years teaching (variable 21) and the achievement tests.

In order to compare the CAI and conventional in-service programs with respect to modern math achievement, as measured by A Test on Modern Mathematics, the following analyses of covariance were conducted:

1. Posttest achievement was the dependent variable with the pretest serving as the covariate.
2. Retention test was the dependent variable and pretest, the covariate.

Tables 5 and 6 in Appendix M present the means, while Tables 7 and 8 present the results of the analyses for covariance.

Taking the above two analyses of covariance collectively it may be observed that no significant differences between instructional methods were found with respect to modern math achievement.

The next part of the analysis dealt with comparing the CAI and conventional groups with regard to attitude toward elementary school mathematics as measured by the Reaction to Elementary School Mathematics (RTESM). In an analysis of covariance where post-program attitude was the criterion variable and pre-program attitude was the covariate, no significant differences were found between the treatment groups. Table 9 in Appendix M shows the means, while Table 10 contains the results of this analysis.

To determine whether differences in attitude toward modern mathematics occurred between the treatment groups, analyses of covariance were performed in which the post-program Attitudes Toward Modern Mathematics Questionnaire (ATMMQ) score was the criterion variable and pre-program ATMMQ score the covariate. The means for these are presented in Table 11 in Appendix M, while the results of these analyses are summarized in Table 12.

In each of the analyses of covariance reported in Table 12, no significant differences between instructional method were found with respect to attitude toward modern mathematics.

The final evaluation to be carried out was concerned with an appraisal of teacher behavior as assessed by the Buck's Observation Schedule and Record for Elementary Mathematics (OScAR-EM). The criterion scores consisted of eight scale scores which are described in Appendix G.

In order to compare the CAI and non-CAI treatment groups with respect to teacher classroom behavior, Buck's (1967) Observation Schedule and Record for Elementary Mathematics (OScAR-EM, see Appendix G) was used. This instrument is divided into eight scales, each designed to measure a different aspect of teacher behavior. Statistically, the data from the first seven scales were analyzed by a Lindquist Type I Analysis of Variance (Lindquist, 1953). The eighth scale was not included in the analysis because it was composed of only one item.

The analysis of variance summary tables for these analyses are presented in Tables 13 to 19 in Appendix M. The results show that no significant differences between treatments were found for any of the scales.

To determine whether differences occurred between teachers, an F-ratio may be obtained by M. S. (teachers) / M. S. (within) with df of 35 and 180. In the tables the F-ratios are enclosed in parentheses. Significant differences between teachers were found on scales three and five. This indicates that these scales find a differentiation among teachers.

Implications and Recommendations

The use of CAI as a means of presenting material to in-service teachers appears to be very feasible. The finding of "no significant differences" between the two treatment groups means that those taught via CAI achieved as well as those in a lecture-discussion group. Despite the fact that the latter had a "live" exposure with the opportunity for interaction with the instructor, they fared no better than those taught by a comparatively less flexible program or what could be considered a "first draft" program. The lecture-discussion group could ask and have their questions answered, while the CAI group could only react to the questions posed by the program. Nevertheless, with careful programming and as a result of continual revision as student answers were processed, the computer program presented material on modern mathematics so that learning was comparable to that achieved by the lecture-discussion group.

There is the indication also evident that, with future refinement, the CAI program could teach for greater mastery than that achieved in the lecture-discussion group. As the needs of increasingly varied samples of teachers are taken into consideration, the opportunity for presenting a multi-branched program can lead to a truly individualized program of instruction. This could in turn enrich the mathematical backgrounds of a varied assortment of teachers.

The potential for the use of CAI as an in-service tool has many implications. The school in an isolated area with a few teachers finds it difficult to provide in-service education because of the inability to secure qualified university personnel. They could provide teachers with individually taught material presented via CAI. Each teacher can achieve the background necessary for her, not only in mathematics but in the future, as additional programs are written, in a wide variety of fields.

In larger communities also, the use of CAI will allow the teacher who is new to the system to acquire the background which the other faculty members may have gained through a "live" in-service during the previous year. The re-education of teachers who have been away from teaching for several years may also be accomplished efficiently through the means of CAI.

In the future, the use of CAI as a means of presenting a variety of materials for a variety of teachers with a variety of purposes can be envisioned. The greatest problem of course remains, as it has since the inception of CAI, the lack of sound programs. Perhaps the fact that the feasibility of its use has been demonstrated will give added impetus to those interested in in-service work with teachers to develop such programs. The hours which must be spent for program development are long. However, once the basic development is completed, the program can be used repeatedly over a period of time, in many sections of the country, so that ultimately it could reach more teachers than the programmer could reach in person. The basic program can be expanded and enriched as student records become available, and thus serve an increasingly varied group.

Reactions to CAI

Each week the participants in the CAI Group were asked to complete the Student Attitude Toward Computer Assisted Instruction Scale (Appendix K). In addition, they were asked to write unidentified critical responses to CAI.

The following comments are a random selection of those received after four weeks of instruction by CAI.

The correct responses are fine. I did not like the chapter on Relations, however. There did not seem to be enough content presented before questions were asked. I got quite confused by all the questions.

I enjoy CAI, but am more tense than I thought I would be and am quite tired afterward.

As time goes on in working on the computer, I am becoming more at ease. At first I felt somewhat tense, but the tension is more relieved.

The process of the machine's telling what is wrong or correct is somewhat monotonous. More variety would make the work interesting.

However, overall I am enjoying the experience of working on the computer. It is a new experience and I believe a worthwhile consideration for future teaching procedures.

The course is interesting because I am fascinated by the machine. I am, however, still in the dark about some of the chapters I have finished. At times it becomes frustrating, but it still holds my interest. I only wish I understood more of what I am doing.

Working with a computer has been a very interesting and exciting experience. I like the idea of being given the correct answer for each question before proceeding.

Before beginning the course I wasn't very excited about working with a machine. Now, I look forward to my class periods, even my Fourth period (9:45-11:00 pm) on Monday evening.

I like this course very much, but I feel that it is "way out" for someone like myself who has absolutely no background in higher math.

If I had a choice and time to study I would stay with each (numeration) base until I thoroughly understood it. This way I've had a "smattering" of each base but don't feel I've really learned it.

This method of study has definite advantages but I wish there was a tutor available to sit down with me and thoroughly explain parts of the course I don't understand.

Despite the fact that at times I do feel quite frustrated, I find this an extremely interesting program. I always leave with the feeling that I want to get back as soon as possible.

While taking CAI, I have found the working with the machines very fascinating. This is so very new to me and I enjoy coming to class. The only criticism I have is with the machine and its typing errors. I feel I am learning New Math.

To say the least, this machine is frustrating at times. I feel it doesn't give me enough explanations on my problems. I feel I should have more explanations or a more detailed explanation on the bases. I'm not condemning the machine. I do find it fascinating when I understand what I'm doing.

I like the CAI course and find it not only interesting but instructive. There are times when I do feel frustrated especially when the answer is correct and rejected by the computer. However, sometimes the mistakes are due to faulty interpretation of the reading material and displays. This brings out the importance of correct reading habits and checking the high lights before attempting the exercises. On the whole, I have found it instructive and beneficial in the various approaches used as I have tried them with my class.

I don't believe computer instruction could ever take the place of traditional 'human' means of instructing, but I do believe it is a valuable asset. It has, in itself, advantages (own rate of speed, etc.) and disadvantages (inability to answer questions you ask it). I don't believe that it is an unwholesome way of learning, but it is surely not the whole way!

The following random selection of responses were received after eight weeks of CAI isntruction.

Because I am finished --- 'Hurrah' I love C.A.I.!' Seriously, though frustrated many times by my inability to communicate with the machine, I have achieved a great deal of learning.

If I were to have another course such as this, I would prefer to have a textbook for pre-study. And, I do prefer this individualized instruction to a classroom situation.

I like this course, but I simply don't have time to study it as I should. Consequently I'm frustrated, because I'm afraid my memory will fail me at test time.

It would be helpful if we could have more assistance from an instructor when you don't understand a part of a given chapter.

As a new teacher and a modern math teacher, I felt modmath 1 was a very good refresher course for me.

I am quite interested in modern math and I enjoyed the course material.

As for the computer, although it was interesting for the most part, it was also frustrating, demanding, and impatient. I realize the computer is a machine and can't bend a bit like teachers can, but some of the computer's demands were just too much.

Modmath was interesting and I enjoyed it but the computer must be improved by better programming, and more "patient" programming before it will ever "begin to replace a teacher."

The use of computers in education is valuable insofar as it is used as a supplement to "traditional" teaching. Pronunciation of words is difficult if new terms are being added to one's vocabulary. There is a need for more recall answers and fewer recognition answers if this can be done without adding mechanical difficulties to the student.

I have really enjoyed the course. I found it to be beneficial and interesting. Now and then it was a little frustrating when the machine would break down or you didn't put down the answer in the exact words or the machine. But I truly did enjoy the course.

I have enjoyed most of the course so far. One thing I did not like was occasionally when they wanted an answer I did not know and they kept asking the same question over and over again. I feel that I have learned a great deal from this course so far.

I feel this is good, but I am getting awfully tired of this whole thing. I have mixed feelings about it and don't feel critical or in favor. I would feel happier if I knew it would do me some good in my teaching. This would be fun if I had nothing else to do with my time.

It is rather difficult to concentrate at such a late hour (10-11 pm). Perhaps I would be more stimulated if this was not the case. At any rate, I no longer find the given responses at all reinforcing, nor do I feel any motivation toward further learning of this nature.

In the beginning, this course was quite challenging and interesting. However, as time moved along, interest and enthusiasm was lost. There was no personality to keep this student interested and enthusiastic.

The manner in which a few of the questions were stated were difficult to understand --- not very many --- but just a few --- enough to infuriate and make a person bang the machine!

I feel this course with CAI may be worthwhile as a refresher course, but not as an introductory course in Modern Math. I can see where a person with little or no math background would come close to experiencing a nervous breakdown! Truly!!

As far as individual differences are concerned, the CAI is a blessing!!

After working with the computer system, I feel I would not take another course offered that uses this technique. Boredom sets in and there is no way to pull yourself out of it--- the computer does not have a good sense of humor or that "personal touch!"

I personally enjoy working on the computer system in learning the modern math. It has challenged me to seek further inforamtion on some of the material which was not too clear, especially the modular numeration system. However, at times I do feel frustrated in trying to find the correct answer and put it in terminology demanded by the course. Since the material is presented in sequence, it can be, as a rule, followed without difficulty. Friday nights seem to be less effective as my thinking faculty is not up to par. I find I do better work in the early part of the week. However, I do look forward to the lesson and become totally absorbed in it. Some of the presentations were helpful to me while teaching modern math and I am very grateful for this opportunity to reinforce what I had already known and also add to my store of knowledge in learning the material of which up to date I was ignorant.

2. *Describe project endeavors in which the anticipated results have exceeded expectations, and those in which results have not measured up to expectations.*

The project exceeded expectations in the following ways.

a) The efficiency of the operation of the modmath program was high. Average time on line was 91.1% (see Appendix J). This means that little time was lost due to breakdown in computer transmission facilities, and teachers were able to use available time optimally.

b) The lack of attrition was surprising. All 39 teachers initially chosen completed the CAI program, the record of those in the lecture-discussion group was similar. (Test data, however, is not available for the total number.)

c) Revision of the program so that it ran more smoothly and effectively was accomplished during the period of operation. Thus, when several teachers had difficulty with a given item, it was revised before other teachers reached this portion of the

course. Additional revisions on the basis of student records from log tapes were also made.

d) The parochial school teachers participated fully in the program. They were able to come in on several occasions when the public school was not in session, thus contributing to operating efficiency.

Expectations which were not fully met include:

It was not possible to avoid scheduling many of the CAI sessions during the late afternoon and evening hours, since too little teacher time was available during the day. However, this in turn meant that the experimental results were not confounded by the time-of-day factor.

3. *Report the effect of the project on the educational institution or agency by discussing what you consider to be the greatest change resulting from the project.*

a) The effect of the in-service work is reflected in the increased scores on the tests. The mathematical background of the teachers involved has increased, with the potential influence of this on pupils.

b) Using computer-assisted instruction as an in-service tool has been demonstrated as feasible.

4. *Report the effect of the project on the cooperating agencies.*

Representatives of the following educational agencies cooperated on the project:

Williamsport Area School District

Dr. Clyde H. Wurster
Superintendent of Schools

Dr. Samuel M. Long
Assistant Superintendent

The Pennsylvania State University	Dr. Harold E. Mitzel Assistant Dean for Research, College of Education
	Dr. C. Alan Riedesel Associate Professor of Education
	Dr. Marilyn N. Suydam Assistant Professor of Education
Lock Haven State College	Mr. C. Herbert Larson Area Curriculum Coordinator
State Department of Public Instruction	Mr. Donald Carroll, Head Bureau of Curriculum Planning
	Mr. Waldo C. Weaver, Coordinator of In-Service Education
St. Boniface Parochial Schools	Monsignor Leo J. Post Superintendent
Annunciation Parochial Schools	Monsignor Frank P. McHugh Superintendent

As a result of this cooperation

a) an in-service program served 78 public and parochial school teachers, with a potential influence on 3,300 pupils.

b) each of the educational agencies listed above benefited from continuing close cooperation.

c) administrators who attended the conference and others who visited the project gained in understanding of the potential in computer-assisted instruction.

5. *Discuss how project information was disseminated.*

a) A one-day invitational conference was held in Williamsport on January 25, 1967. It was attended by 83 school administrators. A copy of the program is included in Appendix N.

b) News articles about the project appeared in:

1) Altoona Mirror

2) Bellefonte-State College Centre Daily Times

3) Harrisburg Patriot

4) Penn State College of Education Newsletter

5) Penn State Daily Collegian

6) Penn State Inquiry

7) Pottsville Republican

8) Williamsport Grit

9) Williamsport Sun-Gazette

10) Project P.U.R.E. from the Department of Public Instruction

11) Educational Technology

c) Speeches describing the project: The project coordinator, Kenneth E. Getschow II, spoke to

1) Association for Childhood Education at Indiana University of Pennsylvania--October 19, 1966

2) Phi Delta Kappa at Indiana University of Pennsylvania--November 16, 1966

3) Lycoming County-Williamsport Schools Joint Institute and In-Service Training Program in Williamsport--February 23, 1967

The project Co-Director, Dr. C. Alan Riedesel, spoke at:

1) Department of Elementary School Principals Meeting in Boston, Massachusetts--April 10, 1967

2) Association of Mathematics Teachers Conference in Tom's River, New Jersey--May 6, 1967

3) Pennsylvania State Elementary Principals Conference at University Park, Pennsylvania--July 14, 1967

4) Workshop for two hundred teachers and administrators at Mankato State College in Minnesota--July 28, 1967

d) A portion of the modmath course material was used in the 24-minute color film "Sign On, Sign Off", produced under other funding.

e) In addition to the news articles cited in section a), other articles for publication in technical journals are in preparation.

f) Individual contacts: In addition to the teachers involved in the CAI treatment group, 25 Williamsport Area High School students, 16 Washington Elementary School sixth-graders, 15 parents and three other interested individuals signed onto the program for varying periods of time and material.

6. *Describe the methods and procedures being developed to carry the project forward without Federal support after the designated approval period.*

Because of the nature of the project, expansion in the Williamsport School District is obviously not practical. The teachers have now received an in-service program in modern mathematics and duplication of this is non-essential at this time.

However, since the project demonstrated the feasibility of use of CAI as an in-service tool, it is being considered as an aspect of projects in other school districts throughout the state. Representatives of the Department of Public Instruction, The Pennsylvania State University and several school districts have been discussing the possibilities. Several proposals for use of CAI are under varying stages of development at this time.

7. *List costs for budget period this narrative report covers:*

$ 63,341.	Total cost
$ 3,023	Total non-Federal support
$ 63,341	Total Federal support under Title III, P.L. 89-10
$ none	Total Federal support other than Title III, P.L. 89-10

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Appendix A

Rationale for the strategies used in modmath

The CAI course was developed at The Pennsylvania State University and written by Dr. C. A. Riedesel and Miss Marilyn Suydam. (See outline and illustrative material Appendix I) Writing on the course began the summer of 1964 and continued through March of 1966. The course is based on the suggestions of mathematical associations and experts in elementary school mathematics education. A rationale for the strategies of the course, the course outline, and a sample of course materials follows.

The course was developed following the assumption that when a learner is faced with a task and then proceeds to bring his powers of thought to bear on the problem maximum learning will take place.

A belief in these assumptions leads to a teaching procedure in which the student is presented with a problem that can be solved by his use of previous knowledge and his thoughtful discovery of the next step of knowledge in the subject. This approach can be called an inductive approach. A deductive approach is usually used in programmed materials. The following diagram contrasts these two approaches to teaching mathematics.

Inductive Approach		Deductive Approach
Student is presented with a problem.		Student is presented with generalization.
If problem is solved by student, he is led to refine his procedure for solving problems of this type.	If student cannot solve problem, he is asked developmental questions which lead to the solution. Student solves similar problem.	Student is quizzed concerning aspects of the generalization.
		Student is presented with illustrative problems in which

Student is asked to develop a generalization.

Student is quizzed concerning aspects of the generalization.

the process of solution is explained to him.

Student applies the generalization to solving problems.

The Modern Mathematics program attempts to make use of a teaching technique similar to the inductive pattern. An illustration of such a pattern for classroom use is as follows:

Purpose of the lesson: To develop an understanding of the use of the inverse (reciprocal) in dividing rational numbers.

The teacher stated: "We've been solving division problems involving the use of rational numbers in several ways. Now let us see if we can find a more efficient method of solution. What are various ways in which we can write $6 \div 3/4$?"

The following ways were suggested by the students:

(a)	(b)	(c)
$6 \div 3/4 = N$	$\frac{6}{\frac{3}{4}} = n$	$\frac{3}{4}\overline{)6}$

The teacher said: "Look at Form (b) $\frac{6}{\frac{3}{4}}$. If we could reduce this fraction, we could solve the problem. What would be the denominator that would make reduction of the fraction simplest to perform?

Pupils suggested that the easiest fraction to reduce would be a fraction with a denominator of 1. The teacher asked: "How could we change the denominator from 3/4 to 1?"

Students recalled that by multiplying by the inverse -- the reciprocal of 3/4, which is 4/3 -- the denominator would be 1. Pupils then said that if the denominator was multiplied by 4/3, the numerator would also have to be multiplied by 4/3 (an application of the role of the identity element for multiplication is 1. $\frac{\frac{4}{3}}{\frac{4}{3}}$ is another name for 1).

The resultant problem was written on the chalkboard in the following form:

$$\frac{6 \times \frac{4}{3}}{\frac{3}{4} \times \frac{4}{3}}$$

Students continued to work division problems in this manner for a time. When the teacher felt that the students had a good understanding of this approach, discussion and guided questions were used to develop the idea that it is not actually necessary to write all of the material -- actually, inverting the divisor accomplishes the desired result. Thus

$$5 \div \frac{1}{2} = 5 \times \frac{2}{1} = 10$$

$$\frac{5 \times \frac{2}{1}}{\frac{1}{2} \times \frac{2}{1}}$$

A teacher using a deductive format for the teaching of inversion would have first explained the approach to the class and then had the students practice its use.

The same teaching strategies will be used with the teacher instruction treatment group.

Appendix B

Course outline for modmath

modmath 1

Sets

A. Set notation
   1. Finite and infinite sets
   2. Elements
   3. Order and correspondence
      a. Equality
      b. Equivalence

B. Subsets
   1. Universal set
   2. Empty set

C. Set operations
   1. Union
   2. Intersection

D. Complement of a set

modmath2

Relationships

A. Common relationships

B. Relationships between sets
   1. Inclusion
   2. Reflexive
   3. Transitive
   4. Sameness
   5. Symmetric

C. R-S-T relations as properties of other relations
   1. Divides
   2. Matching
   3. Equivalence

D. Cardinality

modmath3

Exponents

A. Face value

B. Place value

C. Expanding from exponential form

D. Expressing in exponential form (power of a base)

E. Computation with exponents
   1. Multiplication
   2. Division

F. Zero as an exponent

G. Using expanded notation

modmath4 Our System of Notation

A. Characteristics of our number system
   1. One-to-one correspondence
   2. Essentials of a system of numeration
      a. Symbols
      b. Base
      c. Place value
      d. Zero
      e. Decimal point

B. Mathematical structure
   1. Undefined terms
   2. Definitions of operations
   3. Assumptions
   4. Rules of inference
   5. Theorems

C. Defining and extending the system of numeration
   1. Natural numbers
   2. Whole numbers
   3. Integers
   4. Rational numbers
   5. Irrational numbers
   6. Real numbers

modmath5

Other Number Bases

A. Review of characteristics of base 10
   1. Symbols
   2. Place value
   3. Exponential notation

B. Introduction to base 8
   1. Symbols: counting
   2. Place value
   3. Changing from base 10 to base 8
      a. Finding powers of the base
      b. Division by the base
   4. Changing from base 8 to base 10

C. Introduction to base 5
   1. Changing from base 5 to base 10
   2. Changing from base 10 to base 5

D. Characteristics of any numeration system
   1. Number of digits
   2. Writing the base - 10

E. Introduction to base 12
   1. Changing from base 12 to base 10
   2. Changing from base 10 to base 12

F. Introduction to base 2
   1. Changing from base 10 to base 2
   2. Changing from base 2 to base 10

G. Addition in other bases
   1. Base 5
   2. Base 2

H. Multiplication in other bases
   1. Base 5

modmath6 Addition

A. Counting as the basis for addition

B. Addition as a binary operation

C. Addition as the union of disjoint sets

D. Properties of addition
   1. Closure
   2. Commutativity
   3. Associativity
   4. Identity element

E. Modulus addition
   1. Mod 7
   2. Mod 2

F. Addition basic facts

G. Addition algorithms
   1. Use of place value
   2. Use of properties
   3. Regrouping
   4. Expanded notation forms

H. Historical algorithms
   1. Sandboard method
   2. Scratch method
   3. Hindu method
   4. Front-end addition

I. Checking addition
   1. Excess of nines
   2. Excess of elevens

J. Defining addition

modmath7

Subtraction

A. Subtraction on the number line

B. Subtraction as the inverse of addition

C. Terminology
   1. Addend, missing addend, sum
   2. Minuend, subtrahend, difference

D. Definition of subtraction

E. Subtraction in terms of sets
   1. Complements (equal additions)
   2. Difference between universal set and subset (take-away)

F. Properties
   1. Closure (lack of closure unless set of integers is used)
   2. Commutativity (lack of except under special conditions)
   3. Associativity (lack of except under special conditions)
   4. Compensation; renaming

G. Basic facts
   1. Use of addition table

H. Algorithms
   1. For basic facts
      a. Additive method
      b. Take-away method
   2. For multi-digit examples
      a. Decomposition
         1. Additive
         2. Take-away
      b. Equal additions
         1. Additive
         2. Take-away

I. Checking
   1. By adding
   2. Excess of nines
   3. Excess of elevens
   4. Complementary method
   5. Scratch method

J. Subtraction in non-decimal scales
   1. Base 8

modmath8

Multiplication

A. Multiplication as repeated addition

B. Terminology
   1. Multiplier, multiplicand, product
   2. Factors and product

C. Multiplication in terms of sets

D. Arrays and ordered pairs

E. Properties
   1. Identity element
   2. Closure
   3. Commutativity
   4. Associativity
   5. Distributivity

F. Historical method
   1. "Finger reckoning"

G. Basic facts
   1. Table
   2. Use of properties to determine

H. Multi-digit numerals
   1. Regrouping
   2. Use of place value

I. Lightning method

J. Checking
   1. Use of properties
   2. Excess of nines
   3. Excess of elevens

K. Historical algorithms
   1. Scratch method
   2. Lattice method
   3. Duplation methods

L. Modulus
   1. Mod 2 (e, o)
   2. Mod 7 (days)

modmath9

Division

A. Relation of division to multiplication

B. Terminology
   1. Dividend, divisor, quotient (use of array)
   2. Types
      a. Partition
      b. Measurement

C. Relation of division to subtraction

D. Properties
   1. Closure
      a. Exact division
      b. Inexact division (with remainder)
   2. Commutativity
   3. Associativity
   4. "Right distributivity"
   5. Use of 0 except as divisor
   6. Identity element

E. Algorithms
   1. Basic facts
      a. Relation to multiplication
   2. Multi-digit examples
      a. subtracting groups of the divisor
      b. Use of place value
      c. Estimation of quotient
         1. Approximation
         2. Compensation
         3. Determining divisibility

F. Historical forms
   1. "Galley" method
   2. "A danda" method
   3. Excess of nines

G. Division in base four

modmath10

Integers

A. Defining the set of integers
   1. Negative signed number
   2. Additive inverse

B. Computation with integers

C. Properties of integers
   1. Closure
   2. Commutativity
   3. Associativity
   4. Identity element

D. Order relations of integers

modmath11

Fractions

A. Defining the set of rational numbers

B. Terminology of fractional numerals

C. Interpretations of fractional numerals
   1. Fraction
   2. Rational number (multiplicative inverse)
   3. Indicated division
   4. Ratio or rate pair

D. Characteristics of the set of fractions
   1. Equivalence class
   2. Cross-product test
   3. "Reducing to lowest terms"
      a. Prime numbers
      b. Relative primes

E. Properties of the set of fractions
   1. Commutativity (of addition and multiplication)
   2. Associativity (of addition and multiplication)
   3. Distributivity
   4. Identity element

F. Computation with fractions
   1. Addition with like denominators
   2. Addition with unlike denominators
   3. Finding LCM
   4. Finding GCD
      a. By factorization
      b. From LCM
   5. Subtraction with like denominators
   6. Subtraction with unlike denominators
   7. Multiplication
   8. Division
      a. Common denominator method
      b. Reason for rule of inversion

G. Computation with mixed numerals

modmath12

Decimals

A. Defining the subset of decimals

B. Decimals represented on the number line
   1. Increasing precision of decimals
   2. Fractions equivalent to decimal fractions

C. Division method of converting fractions to decimals

D. Terminating decimals

E. Non-terminating decimals
   1. Repeating
   2. Non-repeating

F. Approximation

G. Changing decimals to fractions

H. Computation with decimals

modmath13

Ratio and Percent

A. Ratio
   1. Expressing ratios
   2. Solving problems with ratios
   3. Using the cross-product method

B. Percent
   1. Three types of problems
      a. What is N% of a number?
      b. What percent is one number of another number?
      c. Find the total (100%) when a percent is known
   2. Five approaches to solving each type of problem
      a. Decimal
      b. Ratio
      c. Unitary-analysis
      d. Formula
      e. Equation

modmath14

Real Numbers

A. Assigning points on the number line
   1. No point on number line of rational numbers for $\sqrt{2}$
   2. Extension to set of real numbers: inclusion of non-repeating, non-terminating decimals
   3. "Nest of intervals" to locate non-repeating, non-terminating decimals
   4. Special role of .2999..., etc.

B. Finding a square root
   1. Repeated approximations method
   2. Traditional algorithm

C. Properties and operations noted to be same as for rational numbers

Appendix C

Sample of modmath Course

SEQUENCE NO.	LABEL	OP CODE	TEXT
05-0090-000	5-9		
05-0090-010		rd	Now let's proceed. Read display 5-B. When finished, press (EOB).
05-0100-000	5-10	qu	Suppose a group of persons in an isolated location were all born with four fingers on each hand. What number base would these persons (with four fingers on each hand) probably have used?
05-0100-010		ca	8
05-0100-020		cb	eight
05-0100-030		cb	base 8
05-0100-040		cb	base eight
05-0100-050		ty	Correct
05-0100-060		un	Think it through more carefully; how many fingers do we have in all? What base do we use? What base would an eight fingered person probably use? Now type your answer.
05-0100-070		un	The answer is 8. Type 8.
05-0110-000	5-11	qu	Remember that base ten has ten single digits. But how many will base eight have?
05-0110-010		ca	8
05-0110-020		cb	eight
05-0110-030		ty	Correct
05-0110-040		un	Base eight has eight single digits. Type eight.
05-0120-000	5-12	qu	Let's try counting in base eight: 1, 2, 3, 4, 5, 6, 7 - and we need a digit to represent the empty set - 0. That's eight digits. If we add 1 more, we reach 8--but 8 is not a digit in base eight. Recall what happens under the same circumstances in base ten; now write the numeral which means "one of the base and zero ones," in base eight.

SEQUENCE NO.	LABEL	OP CODE	TEXT
05-0120-010		ca	10 (eight)
05-0120-020		cb	10 (eight)
05-0120-030		ty	Correct
05-0120-040		ca	10
05-0120-050		ty	10 (eight) is more definitive. In order to clarify whether we are working with base ten numerals or base eight numerals, all base numerals will be written in the following fashion: 5 (eight), meaning "5 in base eight." Remember to use this form.
05-0120-060		un	The number after 7 in base eight is 10 (eight), which means "one group of the base (eight) and zero ones." Type 10 (eight).
05-0130-000	5-13		
05-0130-010		rd	Turn to display 5-C. When you have finished reading, press EOB.
05-0140-000	5-14	qu	Now study the number line in display 5-D. What number should appear after 17 (eight)?
05-0140-010		ca	20 (eight)
05-0140-020		ty	Correct
05-0140-030		ca	20
05-0140-040		ty	Correct - remember it is 20 in base eight.
05-0140-050		wa	18
05-0140-060		wb	18 (eight)
05-0140-070		ty	Do we use the numeral 8 in base eight? One of the base and 8 more would equal 2 of the base. How should 2 of the base be written?
05-0140-080		un	The numeral 17 (eight) would represent 2 of the base. How should 2 of the base be written?
05-0140-090		un	The number 17 (eight) would be 2 of the base or 20 (eight). Type 20 (eight).
05-0150-000	5-15	qu	What numeral will follow 20 (eight).
05-0150-010		ca	21 (eight)

Appendix D

TEST ON MODERN MATHEMATICS - FORM A

C. Alan Riedesel and Marilyn N. Suydam
The Pennsylvania State University

Directions:

Read each question carefully and decide which of the answers is correct. Indicate your answer by blackening the corresponding space on the answer sheet. Use the scrap paper provided for any computation you need to do: please do not mark on the test booklet.

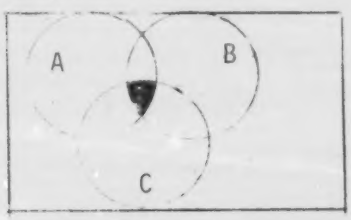
1. Let A be the set of animals, and D be the set of dogs. What is the most correct way of expressing the relationship?

   a) $A \in D$
   b) $D \in A$
   c) $A \subset D$
   d) $D \subset A$
   e) $D \not\subset A$

2. If $C = \{n \mid 3 < n\}$ and $D = \{n \mid n < 12\}$, then what is $C \cap D$? (n is an element in the set of whole numbers)

   a) $\{0, 1, 2, 3, \ldots, 12\}$
   b) $\{0, 1, 2, 13, 14, \ldots\}$
   c) $\{\ldots, 0, 1, 2, 13, 14, \ldots\}$
   d) $\{3,4,5,6,7,8,9,10,11,12\}$
   e) $\{4,5,6,7,8,9,10,11\}$

3. What does the shaded area on the diagram represent?



   a) $(A \cap B) \cap C$
   b) $(A \cup B) \cup C$
   c) $A \cup (B \cap C)$
   d) $A \cap (C \cup B)$
   e) $(A \cap B) \cup C$

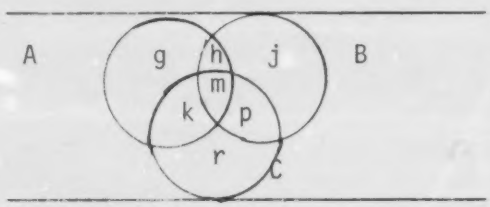
4. Consider: set M = $\{1, 2, 3\}$
   set N = $\{2, 3, 5\}$
   What is the union of set M with set N?

   a) $\{2, 3\}$
   b) $\{1, 2, 3, 2, 3, 5\}$
   c) $\{5\}$
   d) $\{1, 2, 3, 5\}$
   e) none of the above

5. For which set is the following statement true? "A larger number cannot be subtracted from a smaller number."

   a) set of natural numbers
   b) set of real numbers
   c) set of integers
   d) set of rational numbers
   e) none of the above

6. What is the cardinal number associated with set A?



   a) 1
   b) 2
   c) 3
   d) 4
   e) 7

7. Tom and Jim were drawn from the set of students in Jefferson School. The relation (T) exists such that Jim (T) Tom if Jim is taller than Tom. Which of the following properties does the relation (T) have?

a) reflexive
b) symmetric
c) transitive
d) all of the above
e) none of the above

8. Consider set A = {1, 2, 3, 4, 5}
set B = {a, b, c, d, e}
set C = {3, 2, 4, 1, 5}
set D = {f, g, h, i, j}
For which sets does the equality relation exist?

a) A and B
b) A and C
c) B and D
d) all of the above
e) none of the above

9. What is $a^3 \div a^0$, providing $a \neq 0$?

a) 0
b) a^2
c) $a^{3/0}$
d) a^3
e) none of the above

10. Which is an example of an ordinal use of number?

a) 3 groups of apples
b) 48 East Maple Road
c) 12 dozen eggs
d) 237 boxes of candy
e) none of the above

11. Which of the following represents {1, 2, 3, 4, 5, 6, 7, 8, 9, 10} when a numeration system with base eight is used?

a) $1_8, 2_8, 3_8, 4_8, 5_8, 6_8, 7_8, 8_8, 9_8, 10_8$
b) $1_8, 2_8, 3_8, 4_8, 5_8, 6_8, 7_8, 10_8, 11_8$
c) $1_8, 2_8, 3_8, 4_8, 5_8, 6_8, 7_8, 10_8, 11_8, 12_8$
d) $1_8, 2_8, 3_8, 4_8, 5_8, 6_8, 7_8, 8_8, 10_8, 11_8$
e) none of the above

12. What is $5^p \cdot 5^q$?

a) $5^{p \cdot q}$
b) 5^{5p5q}
c) $25^{p \cdot q}$
d) 25^{p+q}
e) 5^{p+q}

13. How is 124 (base five) expressed in expanded notation as sums of the powers of the base?

a) $(1 \times 10^2) + (2 \times 10^1) + (4 \times 10^0)$
b) $(1 \times 10^3) + (2 \times 10^2; + (4 \times 10^1)$
c) $(5^2 \times 1) + (5^1 \times 2) + (5^0 \times 4)$
d) $(1 \times 5^3) + (2 \times 5^2) + (4 \times 5^1)$
e) none of the above

14. What is equivalent to the following?
$(6 \times a^3) + (2 \times a^1) + (4 \times a^0)$

a) $2a\ (3a^2) + 4a$
b) $6a^3 + 2a + 0$
c) $6a^3 + 2 + 0$
d) $12a^4$
e) $6a^3 + 2a + 4$

15. Which represents the largest base six number?

a) 555
b) 666
c) 599
d) 999
e) 699

16. How is 10010 (base two) written in base ten?

a) 18
b) 5005
c) 36
d) 202
e) none of the above

17. What number in base six is represented by the following notation?
$3(6)^3 + 4(6)^2 + 2(6)^1$

a) 54
b) 540
c) 342
d) 804
e) 3420

18. What is 1101 (base two)
+ 1011 (base two)

a) 101000 (base two)
b) 2112 (base two)
c) 11000 (base two)
d) 10001 (base two)
e) none of the above

19. Which is correct terminology?

a) multiplier times multiplicand equals sum
b) factor times factor equals product
c) addend minus addend equals sum
d) subtrahend minus minuend equals difference
e) none of the above

20. Which of the following demonstrates the identity element for addition?

a) a + b = a
b) a + b = c
c) a + a = 2a
d) a + b = b + a
e) none of the above

21. What is the additive inverse of 9?

a) 0
b) 9/1
c) 1/9
d) 1
e) -9

22. For which pair of numbers is exact division possible?

a) 1, 13
b) 2, 178
c) 15, 75
d) all of the above
e) none of the above

23. Consider modulus 9. What is 7 + 5, mod 9?

a) 3
b) 12
c) 4
d) 13
e) none of the above

24. Which shows the use of the distributive property to find n for 43 x 3 = n?

a) (40 x 3) x 3 = (40 x 3) x (3 x 3)
b) (40 + 3) x 3 = (40 x 3) + (3 x 3)
c) (40 + 3) x 3 = 3 x (40 x 3)
d) (40 + 3) x 3 = 3 x (3 x 40)
e) (40 x 3) + 3 = (40 + 3) x (3 + 3)

25. What regrouping was necessary to complete the multiplication in the example shown?

$$\begin{array}{r} 3152 \\ \times\ \ 3 \\ \hline 9456 \end{array}$$

a) 10 ones to 1 ten
b) 10 tens to 1 hundred
c) 10 hundreds to 1 thousand
d) 3 hundreds to 4 hundreds
e) none of the above

26. The product of 475 x 968 would be how many more than the product of 415 x 968?

a) 60 tens x 968
b) 600 tens x 968
c) 6 tens x 968
d) 6 x 968
e) none of the above

27. Which of the following illustrates the relationship between the division algorithm and subtraction?

a) 16 ÷ 4 = (16 - 4 - 4 - 4 - 4)
b) x ÷ y = (y - z) · x
c) 20 ÷ 5 = (20 - 5 - 5 - 5 - 5)
d) $9 \div 3 = 9 - 3^2$
e) none of the above

28. Consider the operation such that $(a \odot b) \odot c = a \odot (c \odot b)$. What properties of this operation $\odot$ (is) (are) demonstrated above?

a) Commutative
b) Associative
c) Distributive
d) Associative and Distributive
e) Associative and Commutative

29. When the equal additions method of subtraction is used, which statement tells what would be done in the following example?

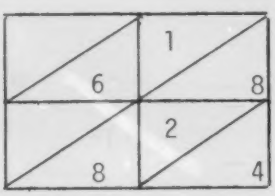
$$\begin{array}{r} 865 \\ -\ 437 \\ \hline \end{array}$$

a) Change 865 to (85 tens and 15 ones)
b) Change 865 to (85 tens and 15 ones) and 437 to (42 tens and 17 ones)
c) Change 437 to (42 tens and 17 ones)
d) Change 437 to (44 tens and 7 ones)
e) Change 865 to (86 tens and 15 ones) and 437 to (44 tens and 7 ones)

30. What is 423 (base five) minus 234 (base five)? (Answer in base five)

a) 179
b) 89
c) 134
d) 324
e) none of the above

31. What two numbers are being multiplied using the historical "lattice" method?



a) 68 x 1824
b) 39 x 23
c) 86 x 4281
d) 26 x 34
e) 618 x 824

32.

a)	(hundreds)	(tens)	(ones)
	2a	3b	1

Consider the above illustration. 2a represents a number in the hundreds column of the dividend. If 2a is divided by a in what column will the first digit of the quotient be?

a) Hundreds
b) Tens
c) Could be in either hundreds or tens
d) Could be in either tens or ones
e) Impossible to tell without specific numbers

33. Which is an example of the partition type of division problem?

a) 16 balloons are divided among 4 boys; how many will each boy get?
b) 3 oranges cost 27¢; how much does one cost?
c) 21 children are divided into 3 groups; how many are there in each group?
d) all of the above
e) none of the above

34. Which of the following is a member of the set of integers?

a) $\sqrt{2}$
b) -2
c) 2 1/2
d) 2.2
e) none of the above

35. Which is true?

a) (-7) + (-3) = 10
b) (+6) - (+2) = -4
c) (-3) - (-5) = 2
d) (-2) - (-4) = -6
e) none of the above

36. Which of the following statements is true concerning fractions?

a) A fraction indicates an expressed division.
b) A fraction indicates a ratio.
c) A fraction may represent a point on a line.
d) all of the above are true.
e) none of the above are true.

37. Which represents the equivalence class for 3/5?

a) {1/5, 2/5, ...}
b) {3/2, 3/4, ...}
c) {9/15, 12/20, ...}
d) {9/25, 27/125, ...}
e) {5/3}

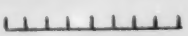
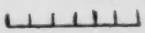
38. What are all the positive exact divisors of 36?

a) 1, 2, 3, 4, 6, 9, 12, 18, 36
b) 2, 3, 4, 6, 9, 12, 18
c) 0, 1, 2, 3, 4, 6, 9, 12, 18, 36
d) 2, 3, 4, 6, 9
e) 1, 2, 3, 4, 6, 9

39. Which of the following represents the largest number?

a) 30.3
b) 30.03
c) 30.0333
d) 30.003
e) 30.303

40. Which decimal indicates how long line A is in relation to line B?

line A  line B 

a) .5
b) .625
c) 1.25
d) .75
e) .33

41. Which illustrates the commutative property for the set of rational numbers?

a) $\frac{m}{n} + \frac{p}{q} = \frac{p}{q} + \frac{m}{n}$

b) $\frac{m}{n} + \frac{p}{q} = mq + pn$

c) $\frac{m}{n} + \frac{p}{q} = \frac{m}{q} + \frac{p}{n}$

d) $\frac{m}{n} + \frac{p}{q} = mp + nq$

e) none of the above

42. What would be the effect on the product if you dropped the zero from 62.50?

$$\begin{array}{r} 62.50 \\ \times\ 3.75 \\ \hline \end{array}$$

a) The product would be the same.
b) The product would be one-tenth as large.
c) The product would be ten times as large.
d) You would point off three places.
e) It would be the same as subtracting zero from the product.

43. What numeral should replace the $\square$ so the ratio of 6 to 7 will be expressed?

$$(\square, 49)$$

a) 6
b) 7
c) 36
d) 42
e) none of the above

44. Consider 6, 12, 20, and 15; what does 60 represent?

a) the greatest common divisor
b) the least common multiple
c) the greatest common factor
d) the least common divisor
e) the greatest common multiple

45. The cost of an item is reduced 30%. What fraction of the original price is the new price?

a) 3/10
b) 3/100
c) 7/10
d) 7/100
e) 40/100

46. Consider: $\frac{6}{25} = \frac{5}{x}$

What is x equal to?

a) 6/5
b) 750
c) 5/6
d) 20 5/6
e) none of the above

47. Which illustrates the ratio or rate-pair idea of solving- "What is 15% of 80?"

a) $x = (.15)\ (80)$
b) $\frac{1}{x} = \frac{15}{80}$
c) $.15x = 80$
d) $\frac{15}{100} = \frac{x}{80}$
e) $\frac{x}{15} = \frac{80}{100}$

48. Which of the following represents a non-terminating, non-repeating decimal?

a) $.\overline{6}$
b) $\sqrt{5}$
c) $\sqrt{13}$
d) 1/5
e) 1/6

49. A sequence of nested intervals begins as follows:
(3,4), (3.3, 3.4), (3.33, 3.34), ...
What are the next two intervals in the sequence?

a) (3.4, 3.5), (3.44, 3.54)
b) (3.333, 3.334), (3.3333, 3.3334)
c) (3.334, 3.335), (3.3334, 3.3335)
d) (3.334, 3.335), (3.336, 3.337)
e) none of the above

50. The result of rounding a number to the nearest hundredth is 12.27. What is the smallest and largest number this represents?

a) greater than 12.2700 but less than 12.2800
b) greater than 12.265 but less than 12.275
c) greater than 12.2 but less than 12.3
d) greater than 12.27 but less than 12.28
e) none of the above

Appendix E

Attitudes Toward Modern Mathematics Questionnaire

Instructions

1. What grade are you teaching now? _____

2. How many years have you been teaching? _____

3. Have you ever had occasion to teach the new math before this year? _____

4. Have you had any training in the new math? _____If so, how much?_____

The best answer to each statement below is your personal opinion. I have covered several different points of view. You may find yourself agreeing strongly with some of the statements, disagreeing just as strongly with others, and perhaps uncertain about others. Whether you agree or disagree with any statement, you can be sure that many other people feel the same as you do.

Mark each statement below in the left margin according to how much you agree with it. Please mark every one. Write in +1, +2, +3, -1, -2, -3, depending upon how you feel in each case.

+1: I agree a little

+2: I agree pretty much

+3: I agree very much

-1: I disagree a little

-2: I disagree pretty much

-3: I disagree very much

1. The new mathematics program gives a meaning to mathematics that traditional mathematics never could.
2. The new program simplifies mathematics.
3. Much of the terminology in the new mathematics is too advanced for the age level at which it is presented.
4. My pupils are acquiring a clearer understanding of the number concepts under the new math program.
5. Children should first and foremost be made aware of the pattern of numbers.

6. The modern mathematics program frequently seems to make the obvious complicated.
7. The new program covers too much material too quickly.
8. Some parts of the new program should be discarded.
9. In mathematics, the most important thing is to get the answer.
10. There is a great deal of superfluous material in the new program.
11. The way in which the new program presents the fundamentals is more logical than the way in which the traditional program did.
12. There is no such thing as using too many manipulative aids.
13. Students learn best by working with a single textbook.
14. My students are gaining a much deeper understanding of the number concepts through the program.
15. The basic principles must be taught from the very beginning as a foundation of the number operations.
16. My pupils would be covering more ground were I still using the traditional program.
17. Large quantities of manipulative aids often serve as a distraction to the learning process.
18. I enjoy teaching my mathematics lessons more now that I am using the new mathematics program.
19. The new program often approaches the same concept from too many angles.
20. The operations should never be taught as a series of mechanical steps, the meaning behind which the student does not know.
21. A good deal of the material in the modern math program must have been dreamed up by university scholars who have never worked with children.
22. Many of the concepts in the new program are too advanced for the grade level at which they are presented.
23. True meaning comes only with self-discovery.
24. The new program is exciting in every way.
25. It is often easier to go back to the old methods when it becomes difficult to get a point across.

26. Constant drill is the only way to teach the facts so that they stick.
27. With the new math program, I am able to provide for the individual needs of my pupils more adequately.
28. My students are learning more from the new math program.
29. Facts are facts, and should be taught as such.
30. I feel my students would be retaining more of their learnings were I using the traditional math.
31. The modern math program is just a passing fad.

Appendix F

NAME _____
(LAST) (FIRST) (INITIAL)

SCHOOL _____ GRADE _____

REACTION TO ELEMENTARY SCHOOL MATHEMATICS

Check (X) only the statements which express your feeling toward arithmetic.

_____1. I feel arithmetic is an important part of the school curriculum.

_____2. Arithmetic is something you have to do even though it is not enjoyable.

_____3. Working with numbers is fun.

_____4. I have never liked arithmetic.

_____5. Arithmetic thrills me, and I like it better than any other subject.

_____6. I get no satisfaction from studying arithmetic.

_____7. I like arithmetic because the procedures are logical.

_____8. I am afraid of doing word problems.

_____9. I like working all types of arithmetic problems.

_____10. I detest arithmetic and avoid using it at all times.

_____11. I have a growing appreciation of arithmetic through understanding its values, applications, and processes.

_____12. I am completely indifferent to arithmetic.

_____13. I have always liked arithmetic because it has presented me with a challenge.

_____14. I like arithmetic, but I like other subjects just as well.

_____15. The completion and proof of accuracy in arithmetic gave me satisfaction and feelings of accomplishment.

Before scoring your attitude scale, place an "x" on the line below to indicate where you think your general feeling toward arithmetic might be.

11 10 9 8 7 6 5 4 3 2 1

Favor Strongly Neutral Strongly Against

Appendix G

Buck's Observation Scale and Record for Elementary Mathematics and Description of Eight Scale Scores

SECTION I

- [ ] add
- [ ] chlkbrd-cmpts
- [ ] chlkbrd-tchr us
- [ ] dcml
- [ ] dvde
- [ ] envrnmntl obj
- [ ] mltply, mltplctn
- [ ] nmbr
- [ ] nmrl
- [ ] rgpng, rnmng
- [ ] rmndr
- [ ] sbtrt
- [ ] sum
- [ ] zr

SECTION II

- [ ] aks ppl ilstrt answr
- [ ] aks ppl ho h slvd prblm
- [ ] acpts soltn w/o cmnt
- [ ] alws any ppl rstte cntrbtn
- [ ] encrgs altrnt sltn
- [ ] rqsts ppl rpt stmnt, cntrbtn
- [ ] ldng or strctrng gustn, stmnt
- [ ] lcts ky cntrbtr, cls on hm
- [ ] mks :prvng rmrk
- [ ] rfrs ppl qustn to anthr ppl
- [ ] rqsts anthr ppl rpt stmnt
- [ ] rphrss or rstrctrs ppl cntrbtn
- [ ] wts fr ppl frmlte, thnk answr

SECTION III

- [ ] agrs w tchr
- [ ] exprss dsgrmnt w tchr
- [ ] ofrs hypths
- [ ] ofrs psbl sltn
- [ ] sks tchr hlp
- [ ] volntr reltd, prtnt infrmtn
- [ ] gvs verbl asstnce to anthr ppl

SECTION IV

- ☐ ads enrchment for ppl
- ☐ apls lgc mthmtcl ids
- ☐ dvlps frmla, rle fr prcde
- ☐ intrls mthmtcl ids
- ☐ intrdcs cncpt thru prblm
- ☐ qustns crct answr
- ☐ uses ilstrtn
- ☐ uses mthmtcl rl or prncple
- ☐ uses scl aplctn

BUCK'S
ELEMENTARY MATHEMATICS OBSERVATION
SCALE

Date_____

Observer's Name_____

Observation Number_____

School Code_____

Teacher Code_____

Treatment Number_____

Grade Level_____

Appendix H

TABLE 1. FREQUENCY DISTRIBUTIONS ON THE PRE-, POST-, AND RETENTION TESTS

Score	Pretest			Posttest			Retention Test		
	Total Group	Lecture Discussion Group	CAI Group	Total Group	Lecture Discussion Group	CAI Group	Total Group	Lecture Discussion Group	CAI Group
48-50	0	0	0	0	0	0	0	0	0
45-47	0	0	0	0	0	0	0	0	0
42-44	0	0	0	4	1	3	2	1	1
39-41	0	0	0	3	2	1	3	0	3
36-38	1	1	0	6	3	3	3	1	2
33-35	2	0	2	7	3	4	4	2	2
30-32	2	1	1	9	3	6	7	3	4
27-29	2	0	2	10	4	6	7	3	4
24-26	4	2	2	9	3	6	11	5	6
21-23	12	5	7	7	4	3	12	6	6
18-20	8	5	3	7	4	3	2	0	2
15-17	12	6	6	6	5	1	8	7	1
12-14	8	3	5	4	2	2	3	2	1
9-11	11	6	5	3	2	1	2	1	1
6-8	8	5	3	3	3	0	3	2	1
3-5	5	3	2	0	0	0	0	0	0
0-2	3	2	1	0	0	0	0	0	0

TABLE 2. PRE AND POSTTEST SCORES AND DIFFERENCES BETWEEN OF LECTURE-DISCUSSION GROUP

SUBJECT	PRE	POST	DIFFERENCE
LA	37	37	0
LB	32	31	- 1
LC	17	20	+ 3
LD	0	11	+11
LE	8	10	+ 2
LF	14	22	+ 8
LG	22	25	+ 3
LH	25	33	+ 8
LI	3	15	+12
LJ	21	19	- 2
LK	16	13	- 3
LL	13	16	+ 3
LM	11	26	+15
LN	18	27	+ 9
LO	6	12	+ 6
LP	22	40	+28
LQ	24	27	+ 3
LR	12	16	+ 4
LS	16	33	+17
LT	8	19	+11
LU	11	21	+10
LV	4	7	+ 3
LW	6	7	+ 1
LX	21	35	+14
LY	4	29	+25
LZ	19	28	+ 9
LAA	10	8	- 2
LBB	15	37	+12
LCC	11	16	+ 5
LDD	0	21	+21
LEE	20	40	+20
LFF	7	16	+ 9
LGG	18	32	+14
LHH	17	20	+ 3
LII	22	43	+21
LJJ	10	23	+13
LKK	18	32	+14
LLL	15	24	+ 9
LMM	11	37	+26

TABLE 3. PRE AND POSTTEST SCORES AND DIFFERENCES BETWEEN SCORES OF CAI GROUP

SUBJECT	PRE	POST	DIFFERENCE
CA	24	43	+19
CB	23	30	+ 7
CC	18	22	+ 4
CD	21	29	+ 8
CE	32	44	+12
CF	9	24	+15
CG	19	31	+12
CH	34	44	+10
CI	21	29	+ 8
CJ	14	18	+ 4
CK	13	22	+ 9
CL	33	35	+ 2
CM	3	22	+19
CN	15	30	+15
CO	29	38	+ 9
CP	12	27	+ 15
CQ	22	38	+16
CR	12	25	+13
CS	23	31	+ 8
CT	7	26	+19
CU	29	40	+11
CV	17	29	+12
CW	16	33	+17
CX	10	13	+ 3
CY	11	17	+ 6
CZ	15	27	+12
CAA	22	31	+ 9
CBB	21	34	+13
CCC	11	18	+ 7
CDD	0	20	+20
CEE	26	32	+ 6
CFF	3	11	+ 8
CGG	16	34	+18
CHH	12	24	+12
CII	20	36	+16
CJJ	6	25	+19
CKK	5	13	+ 8
CLL	17	29	+12
CMM	10	24	+13

Appendix I

EXPONENTS

Our arithmetic symbols have several different meanings which allow us to extend our number system as far as we wish and, at the same time, write in simple, compact notation. Some of these meanings are:

FACE VALUE: Actual value attached to each digit, 0, 1, 2,..., 9
3 represents "threeness"
6 represents "sixness"

PLACE VALUE: Assigns to the digits particular positions from right to left, each position having certain multiples of 10 (in the decimal system) for its value, such as ones, tens, hundreds, thousands. For places from the decimal point to the right, we use fractional multiples.

BASE: This is a particular value used as the foundation or basis of a number system. The decimal system uses Base 10, the Binary system uses Base 2. The base is multiplied by itself to achieve the positional or place values, ... This is also the name used for any factor to be multiplied by itself.

POWER: The number of times a factor is multiplied by itself.

EXPONENT: The small numeral (superscript) written above and to the right of the base numeral to indicate the POWER OF THE BASE.

Multiples	Factors		Exponents show Powers of the base
100	= 10 x 10	10 as a factor 2 times	10^2
1000	= 10 x 10 x 10	10 as a factor 3 times	10^3
10,000	= 10 x 10 x 10 x 10	10 as a factor 4 times	10^4

Different Bases:	Factor	Exponent
$9 \times 9 \times 9 \times 9 \times 9 = 9^5$	9	5
$6 \times 6 \times 6 \times 6 \times 6 \times 6 \times 6 \times 6 = 6^8$	6	8
$3 \times 3 \times 3 \times 3 = 3^4$	3	4
$12 \times 12 \times 12 = 12^3$	12	3

5^2 is often read, "five squared"

5^3 is often read, "five cubed"

Thousands	Hundreds	Tens	Ones
1000	100	10	1
10x10x10	10x10	10	1
10^3	10^2	10^1	10^0
	6	2	8
5	3	7	4

$628 = 600 + 20 + 8$

$(6 \times 100) + (2 \times 10) + (8 \times 1)$

$(6 \times 10 \times 10) + (2 \times 10) + (8 \times 1)$

$(6 \times 10^2) + (2 \times 10^1) + (8 \times 10^0)$

$5374 = (5 \times 10^3) + (3 \times 10^2) + (7 \times 10^1) + (4 \times 10^0)$

Multiplication of numbers expressed in exponential form is possible. They must have the same base and the operation is simply addition of the exponents. Example:

$6^2 \times 6^3 = 6^5$ $\quad 6^2 = 36,\ 6^3 = 216,\ 6^5 = 7776$

$2^3 \times 2^2 = 2^5$ $\quad 2^5 = 32$

$$\begin{array}{r} 216 \\ \times\ 36 \\ \hline 1296 \\ 648 \\ \hline 7776 \end{array}$$

As multiplication has the operation of addition of the exponents, division uses the operation of subtraction on the exponents.

$2^3 \div 2^2 = 2^1$ or $\underline{2}$ $\quad 2^3 = 8,\ 2^2 = 4,\ 8 \div 4 = \underline{2}$

Addition and subtraction of the bases by using operations on the exponents are not possible.

Scientific Notation: Expressing numbers in decimals by using a pair of factors. One factor represents a number between 1 and 10 while the other represents a power of 10 by the use of exponents.

6400 may be divided by 10^2 resulting in 6.4×10^2 as the scientific notation

2.93×10^4 would originally have been written 29,300

.0025 is expressed as 2.5×10^{-3} which means

$$2.5 \times \frac{1}{10 \times 10 \times 10} = 2.5 \frac{1}{1000} = 2.5 \times 10^{-3}$$

Whole numbers have positive exponents, decimal fractions are expressed by negative exponents.

Zero Exponent: $2^3 \div 2^3 = 2^0 = 1$

$8 \div 8 = 1$

Exercises

1. In 3,962, what is the face value of the "9"? a. _____

   What face value is indicated by the "2"? b. _____

2. The third position to the left of the decimal point has what place value? The second position to the right of the decimal point? a. _____ b. _____

3. Write in expanded notation:

   a. 295 _____

   b. 304 _____

   c. 4951 _____

   d. 6038 _____

4. Change the following from exponential notation to another form:

   a. 6^5 = _____

   b. 4^3 = _____

   c. 13^2 = _____

   d. 25^3 = _____

   e. 10^0 = _____

5. Write solutions for the following:

   a. $10^4 \times 10^2$ = _____

   b. $6^3 \times 6^7$ = _____

   c. $8^5 \times 8^0$ = _____

   d. $11^1 \times 11^1$ = _____

   e. 7×7 = _____

   f. $8^7 \times 9^2$ = _____

   g. $4^4 \div 4^2$ = _____

   h. $12^8 \div 12^2$ = _____

   i. $10^3 \div 10^3$ = _____

   j. $9^6 \div 9^0$ = _____

   k. $5^4 \div 5^5$ = _____

   l. $10^8 \div 10^4$ = _____

6. Solve:

   a. $5^6/5^6$ = _____

   b. $\frac{10^4}{10^4}$ = _____

   c. $6^2 \div 6^2$ = _____

   d. $9^3 \div 9^0$ = _____

7. Write the following in expanded notation using powers of the base:

   a. 3954 = _____

   b. 6208 = _____

   c. 481 = _____

   d. 3600 = _____

8. Change the following to exponential notation:

   a. 1,000,000 = _____

   b. 1,000,000,000,000 = _____

   c. 10,000,000 = _____

   d. 100,000,000 = _____

9. Write the following in scientific notation:

   a. 24,000 = _____

   b. 136,000 = _____

   c. 4,268,900,000 = _____

   d. .0019 = _____.

10. Write the values of the numbers expressed on the left for each of the powers of the base heading the columns:

	Fourth Power	Third Power	Second Power	First Power	Zero Power
2					
6					
5					
3					
10					

Answers

1. a. (9) or "nineness" b. (2) or "twoness"

2. a. Hundreds b. Hundredths

3. a. $295 = (2 \times 100) + (9 \times 10) + (5 \times 1)$
   b. $304 = (3 \times 100) + (0 \times 10) + (4 \times 1)$
   c. $4951 = (4 \times 1000) + (9 \times 100) + (5 \times 10) + (1 \times 1)$
   d. $6038 = (6 \times 1000) + (0 \times 100) + (3 \times 10) + (8 \times 1)$

4. a. $6 \times 6 \times 6 \times 6 \times 6$
   b. $4 \times 4 \times 4$
   c. 13×13
   d. $25 \times 25 \times 25$
   e. 1

5. a. 10^6 d. 11^2 g. 4^2 j. 9^6
   b. 6^{10} e. 7^2 h. 12^6 k. 5^{-1}
   c. 8^5 f. No solution i. 10^0 l. 10^4

6. a. 5^0 b. 10^0 c. 6^0 d. 9^3

7. a. $3954 = (3 \times 10^3) + (9 \times 10^2) + (5 \times 10^1) + (4 \times 10^0)$
   b. $6208 = (6 \times 10^3) + (2 \times 10^2) + (0 \times 10^1) + (8 \times 10^0)$
   c. $481 = (4 \times 10^2) + (8 \times 10^1) + (1 \times 10^0)$
   d. $3600 = (3 \times 10^3) + (6 \times 10^2) + (0 \times 10^1) + (0 \times 10^0)$

8. a. 10^6 b. 10^{12} c. 10^7 d. 10^8

9. a. 2.4×10^4 b. 1.36×10^5 c. 4.2689×10^9 d. 1.9×10^{-3}

10.

	Fourth Power	Third Power	Second Power	First Power	Zero Power
2	16	8	4	2	1
6	1296	216	36	6	1
5	625	125	25	5	1
3	81	27	9	3	1
10	10,000	1,000	100	10	1

Appendix J

CODED LIST OF CAI GROUP

CODE	FINISH DATE	TEST DATE	TOTAL TIME ON COURSE
MA	November 28, 1966	December 1, 1966	19:38
MB	November 28, 1966	December 1, 1966	21:01
MC	November 28, 1966	November 30, 1966	21:41
MD	November 28, 1966	December 1, 1966	18:43
ME	December 2, 1966	December 6, 1966	20:04
MF	December 2, 1966	December 8, 1966	23:46
MG	December 2, 1966	December 5, 1966	19:59
MH	December 5, 1966	December 8, 1966	20:27
MI	December 5, 1966	December 12, 1966	20:35
MJ	December 7, 1966	December 12, 1966	23:01
MK	December 8, 1966	December 12, 1966	23:31
ML	December 8, 1966	December 14, 1966	14:37
MM	December 9, 1966	December 13, 1966	22:41
MN	December 9, 1966	December 13, 1966	20:56
MO	December 9, 1966	December 13, 1966	22:33
MP	December 12, 1966	December 15, 1966	28:00
MQ	December 12, 1966	December 13, 1966	25:25
MR	December 12, 1966	December 19, 1966	25:43
MS	December 12, 1966	December 14, 1966	22:24
MT	December 13, 1966	December 16, 1966	25:14
MU	December 13, 1966	December 19, 1966	22:53
MV	December 13, 1966	December 19, 1966	24:15
MW	December 14, 1966	December 14, 1966	28:22
MX	December 14, 1966	December 15, 1966	28:31
MY	December 14, 1966	December 20, 1966	31:15
MZ	December 14, 1966	December 15, 1966	26:51
MAA	December 14, 1966	December 15, 1966	25:54
MBB	December 15, 1966	December 19, 1966	26:29
MCC	December 15, 1966	December 19, 1966	27:59
MDD	December 15, 1966	December 19, 1966	29:22
MEE	December 15, 1966	December 21, 1966	19:37
MFF	December 16, 1966	December 19, 1966	24:23
MGG	December 19, 1966	December 21, 1966	27:38
MHH	December 19, 1966	December 21, 1966	33:50
MII	December 20, 1966	January 5, 1967	29:51
MJJ	December 21, 1966	December 29, 1966	35:47
MKK	December 22, 1966	January 4, 1967	33:49
MLL	January 4, 1967	January 5, 1967	36:02
MMM	January 24, 1967	January 25, 1967	46:35

Appendix K

Summary of On-Line Terminal Usage

Week	hours used	hours unused	hours down
1	60.5 %	8.0 %	31.5 %
2	89.0 %	2.5 %	8.5 %
3	93.15%	0.3 %	6.55%
4	93.98%	0.04%	5.98%
5	93.0 %	0.00%	7.8 %
6	97.33%	0.08%	3.12%
7	100.44%	0.11%	0.38%
8	92.8 %	0.00%	7.9 %
9	94.5 %	0.99%	5.25%
10	94.5 %	0.03%	6.38%
11	93.35%	0.56%	6.53%
Average	91.1 %	1.1 %	8.2 %

Appendix L

STUDENT ATTITUDE TOWARD COMPUTER ASSISTED INSTRUCTION

This is not a test of information; therefore, there is no one "right" answer to a question. We are interested in your opinion on each of the statements below. Your opinions will be strictly confidential. Do not hesitate to put down exactly how you feel about each item.

NAME_____ DATE_____

CIRCLE THE RESPONSE THAT MOST NEARLY REPRESENTS YOUR REACTION TO EACH OF THE STATEMENTS BELOW.

1. The method by which I was told whether I had given a right or wrong answer became montonous.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

2. The material presented to me by Computer Assisted Instruction caused me to feel that no one really cared whether I learned or not.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

3. While taking Computer Assisted Instruction I felt challenged to do my best work.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

4. While taking Computer Assisted Instruction I felt isolated and alone.

All the time	Most of the time	Some of the time	Only occasionally	Never

5. While taking Computer Assisted Instruction I felt as if someone were engaged in conversation with me.

All the time	Most of the time	Some of the time	Only occasionally	Never

6. As a result of having studied some material by Computer Assisted Instruction, I am interested in trying to find out more about the subject matter.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

7. I was more involved in running the machine than in understanding the material.

All the time	Most of the time	Some of the time	Only occasionally	Never

8. Computer Assisted Instruction makes the learning too mechanical.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

9. I felt as if I had a private tutor while on Computer Assisted Instruction.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

10. I found it difficult to concentrate on the course material because of the hardware.

All the time	Most of the time	Some of the time	Only occasionally	Never

11. The Computer Assisted Instruction situation made me feel quite tense.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

12. Computer Assisted Instruction is an inefficient use of the student's time.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

13. Concerning the course material I took by Computer Assisted Instruction, my feeling toward the material before I came to Computer Assisted Instruction, was

Very favorable	Favorable	Indifferent	Unfavorable	Very unfavorable

14. Concerning the course material I took by Computer Assisted Instruction, my feeling toward the material after I had been on Computer Assisted Instruction.

Very favorable	Favorable	Indifferent	Unfavorable	Very unfavorable

15. While on Computer Assisted Instruction I encountered mechanical malfunctions.

Very often	Often	Occasionally	Seldom	Very Seldom

16. I felt frustrated by the Computer Assisted Instruction situation.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

17. The Computer Assisted Instruction approach is inflexible.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

18. Even otherwise interesting material would be boring when presented by Computer Assisted Instruction.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

19. In view of the effort I put into it, I was satisfied with what I learned while taking Computer Assisted Instruction.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

20. In view of the amount I learned, I would say Computer Assisted Instruction is superior to traditional instruction.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

21. With a course such as I took by Computer Assisted Instruction, I would prefer Computer Assisted Instruction to traditional instruction.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

22. I am not in favor of Computer Assisted Instruction because it is just another step toward de-personalized instruction.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

Appendix M

Table 4

CORRELATION MATRIX. RELATIONSHIP AMONG VARIABLES FOR THE TOTAL GROUP (N = 67)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2	.73																					
3	.79	.90																				
4	.22	.13	.13																			
5	-.10	-.04	-.05	-.65																		
6	-.24	-.28	-.29	-.13	.36																	
7	.45	.44	.47	.53	-.30	-.65																
8	.39	.32	.40	.40	-.21	-.11	.38															
9	-.24	-.28	-.29	-.38	.44	.28	-.38	-.64														
10	-.25	-.25	-.28	.02	.18	.58	-.31	-.06	.31													
11	.52	.44	.49	.18	-.17	-.52	.62	.50	-.33	-.58												
12	.30	.29	.26	.26	-.31	-.32	.43	.09	-.21	-.30	.41											
13	.39	.33	.28	.31	-.31	-.31	.39	.20	-.34	-.22	.34	.65										
14	.53	.40	.41	.29	-.25	-.21	.39	.28	-.19	-.28	.50	.75	.61									
15	.42	.36	.35	.24	-.18	.16	.36	.27	-.25	-.13	.38	.54	.66	.71								
16	-.47	-.28	-.39	-.41	.27	.15	-.40	-.39	.29	.05	-.35	.03	-.08	-.13	-.12							
17	.46	.30	.31	.41	-.30	-.15	.35	.23	-.28	-.09	.27	.28	.20	.31	.17	-.47						
18	.10	.12	.11	.31	-.10	.20	.09	.30	-.22	-.16	.01	.22	.18	.11	.08	-.12	.35					
19	.43	.17	.25	.32	-.21	-.11	.28	.20	-.22	-.05	.27	.25	.13	.30	.14	-.44	.79	.16				
20	.09	.13	.09	.30	-.09	.23	.06	.28	-.20	-.19	-.02	.21	.17	.09	.06	-.08	.32	.98	.13			
21	-.42	-.32	-.41	-.35	.12	-.05	-.27	-.46	.25	.01	-.35	.14	.03	-.03	-.13	.80	-.29	-.08	-.28	-.05		
22	.10	.03	.03	-.14	.09	-.03	.01	-.15	.19	-.13	.19	.35	.15	.32	.20	.09	-.03	-.14	.03	-.15	.15	
23	.09	.15	.12	.16	.02	.01	.11	.05	.09	-.02	.18	.15	-.02	.20	-.07	-.24	.20	.16	.18	.14	-.22	-.07

1--pretest-right
2--posttest-right
3--retention-right
4--pre ATMMQ ++
5--pre ATMMQ +-
6--pre ATMMQ -+
7--pre ATMMQ --
8--post ATMMQ ++
9--post ATMMQ +-
10--post ATMMQ -+
11--post ATMMQ --
12--pre RTESM attitude
13--pre RTESM scale value
14--post RTESM attitude
15--post RTESM scale value
16--Age
17--New math previous training 0=No 1=Yes
18--New math previous teaching experience 0=No 1= Yes
19--How much previous training - years
20--How much previous teaching - years
21--Total years teaching
22--Grade now teaching
23--Total time on computer (CAI group only)

TABLE 5. MEANS FROM ANALYSIS OF COVARIANCE ON POST PROGRAM ACHIEVEMENT WITH PRE-TEST AS THE COVARIATE

Treatment	Covariate Mean	Unadjusted Mean	Adjusted Mean
CAI	17.76	28.85	27.48
Non-CAI	14.45	24.45	25.87

TABLE 6. MEANS FROM ANALYSIS OF COVARIANCE ON RETENTION TEST WITH PRE-TEST AS THE COVARIATE

Treatment	Covariate Mean	Unadjusted Mean	Adjusted Mean
CAI	17.76	26.71	25.37
Non-CAI	14.45	22.55	23.92

TABLE 7. RESULTS OF ANALYSIS OF COVARIANCE ON POSTTEST ACHIEVEMENT USING PRETEST AS A COVARIATE

Source	df	S.S.	M.S.	F	P
Teaching Method	1	41.52	41.52	<1.00	N.S.
Error	64	2798.77		43.73	
Total	65	2840.29			

TABLE 8. RESULTS OF ANALYSIS OF COVARIANCE ON RETENTION TEST USING PRETEST AS A COVARIATE

Source	df	S.S.	M.S.	F	P
Teaching Method	1	33.91	33.91	1.18	N.S.
Error	64	1832.81	28.64		
Total	65	1866.72			

TABLE 9. MEANS FROM ANALYSIS OF COVARIANCE ON POST -PROGRAM RTESM ATTITUDE USING PRE-PROGRAM RTESM SCORES AS THE COVARIATE

Treatment	Covariate Mean	Unadjusted Mean	Adjusted Mean
CAI	7.46	7.45	7.40
Non-CAI	7.33	7.28	7.33

TABLE 10. RESULTS OF ANALYSIS OF COVARIANCE ON POST-PROGRAM RTESM ATTITUDE USING PRE-PROGRAM RTESM ATTITUDE SCORE AS A COVARIATE

Source	df	S.S.	M.S.	F	P
Teaching Method	1	9.03	9.03	<1.00	N.S.
Error	64	7867.26	122.93		
Total	65	7876.29			

TABLE 11. MEANS FROM ANALYSIS OF COVARIANCE ON POST-PROGRAM ATMMQ ATTITUDE USING PRE-PROGRAM SCORES AS THE COVARIATE

Treatment	Covariate Mean	Unadjusted Mean	Adjusted Mean
ATMMQ Pos. - Pos.			
CAI	11.12	11.18	10.92
Non-CAI	9.73	10.58	10.84
ATMMQ Pos. - Neg.			
CAI	2.03	2.32	2.31
Non-CAI	1.97	2.15	2.16
ATMMQ Neg. - Pos.			
CAI	5.74	6.97	7.03
Non-CAI	5.91	7.09	7.03
ATMMQ Neg. - Neg.			
CAI	10.35	10.76	10.26
Non-CAI	8.52	8.73	9.25

TABLE 12. RESULTS OF ANALYSES OF COVARIANCE ON POST-PROGRAM ATMMQ SCORES USING THE PRE-PROGRAM ATMMQ SCORE AS A COVARIATE

ATMMQ Pos.-Pos.

Source	df	S.S.	M.S.	F	P
Teaching Method	1	0.12	0.12	<1.00	N.S.
Error	64	561.05	8.77		
Total	65	561.17			

ATMMQ Pos.-Neg.

Source	df	S.S.	M.S.	F	P
Teaching Method	1	0.36	0.36	<1.00	N.S.
Error	64	268.02	4.19		
Total	65	268.38			

ATMMQ Neg.-Pos.

Source	df	S.S.	M.S.	F	P
Teaching Method	1	0.00	0.00	<1.00	N.S.
Error	64	1047.41	16.37		
Total	65	1047.41			

ATMMQ Neg.-Neg.

Source	df	S.S.	M.S.	F	P
Teaching Method	1	16.43	16.43	1.50	N.S.
Error	64	698.96	10.92		
Total	65	715.39			

TABLE 13. RESULTS OF ANALYSIS OF VARIANCE ON SCALE ONE
Teacher directing strategies and pupil response

Source	df	S.S.	M.S.	F	P
Teachers	35	153.16	4.38	(1.44)	(N.S.)
Treatments	1	0.01	0.01	0.00	N.S.
Error	34	153.16	4.51		
Within	180	549.50	3.05		
Total	215	702.66			

TABLE 14. RESULTS OF ANALYSIS OF VARIANCE ON SCALE TWO
Pupil-Teacher interaction

Source	df	S.S.	M.S.	F	P
Teachers	35	35.46	1.01	(0.90	(N.S.)
Treatments	1	2.04	2.04	2.08	N.S.
Error	34	33.42	0.98		
Within	180	202.50	1.12		
Total	215	237.96			

TABLE 15. RESULTS OF ANALYSIS OF VARIANCE ON SCALE THREE
Teacher vocabulary emphasis

Source	df	S.S.	M.S.	F	P
Teachers	35	109.48	3.13	(2.93)	(<.001)
Treatments	1	5.35	5.35	1.75	N.S.
Error (Teachers within treatment)	34	104.13	3.06		
Within	180	192.67	1.07		
Total	215	302.15			

TABLE 16. RESULTS OF ANALYSIS OF VARIANCE ON SCALE FOUR
Classroom discussion strategies

Source	df	S.S.	M.S.	F.	P
Teachers	35	44.26	1.26	(0.71)	(N.S.)
Treatments	1	0.17	0.17	0.13	N.S.
Error	34	44.09	1.30		
Within	180	319.00	1.77		
Total	215	363.26			

TABLE 17. RESULTS OF ANALYSIS OF VARIANCE ON SCALE FIVE
Teacher motivating behavior

Source	df	S.S.	M.S.	F	P
Teachers	35	65.05	1.86	(2.33)	(<.01)
Treatments	1	0.00	0.00	0.00	N.S.
Error	34	65.05	1.91		
Within	180	144.50	0.80		
Total	215	209.55			

TABLE 18. RESULTS OF ANALYSIS OF VARIANCE ON SCALE SIX
Classroom interaction in problem solving

Source	df	S.S.	M.S.	F	P
Teachers	35	46.79	1.34	(1.30)	(N.S.)
Treatments	1	0.04	0.04	0.03	N.S.
Error	34	46.75	1.38		
Within	180	184.83	1.03		
Total	215	231.62			

TABLE 19. RESULTS OF ANALYSIS OF VARIANCE ON SCALE SEVEN
Teacher vocabulary reference to fundamental operations

Source	df	S.S.	M.S.	F	P
Teachers	35	47.50	1.64	(1.44)	(N.S.)
Treatments	1	1.19	1.19	0.72	N.S.
Error	34	56.32	1.66		
Within	180	204.33	1.14		
Total	215	261.83			

Appendix N
Conference Program

CReWS CONFERENCE

Friday, May 26, 1967 - J. Orvis Keller Building
(Conference Center)

Coffee on Arrival

10:15 Cooperative Research with Schools:

Dr. Alan Riedesel, Director, Center for Cooperative Research with Schools

10:45 The University's Role in Public School Research:

Dr. Harold Mitzel, Assistant Dean for Research, College of Education, The Pennsylvania State University

11:15 Problems of School Research:

Dr. Robert Lathrop, Chairman, Graduate Faculty, College of Education, The Pennsylvania State University

12:00 Lunch at the Conference Center

1:30 Questions and Answers:
CReWS staff--Dr. Jack N. Sparks, Miss Marilyn N. Suydam, Dr. Riedesel

2:15 Panel: The Role of CReWS and Other Agencies

Dr. Paul Bixby, Associate Dean, College of Education, The Pennsylvania State University

Dr. Bruce Brummitt, Superintendent, State College Area Schools

Dr. Walter DeLacy, Executive Secretary, Pennsylvania School Study Council

Dr. Frank Palecki, Associate Director, Title III Area J Center, Lock Haven

Dr. Helen Snyder, Director, State College Branch office, Appalachia Educational Laboratory

3:00 Announcements

3:00- 5:00 The CReWS staff will be available for conferences